Fish & Wildlife Division

RESOURCE DATA AND SPECIES AT RISK SECTION

Status of the Burrowing Owl (*Athene cunicularia*) in Alberta:

Update 2005

Alberta Wildlife Status Report No. 11 (Update 2005)

Alberta Conservation Association

Alberta

Status of the Burrowing Owl (*Athene cunicularia*) in Alberta:

Update 2005

Prepared for:
Alberta Sustainable Resource Development (SRD)
Alberta Conservation Association (ACA)

Update prepared by:
Danielle Todd

Much of the original work contained in the report was prepared by Troy Wellicome in 1997.

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PREFACE

Every five years, the Fish and Wildlife Division of Alberta Sustainable Resource Development reviews the general status of wildlife species in Alberta. These overviews, which have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*) and 2000 (*The General Status of Alberta Wild Species 2000*), assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A key objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are *At Risk* or *May Be At Risk* in the province, that are of uncertain status (*Undetermined*), or that are considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development. They are intended to provide detailed and up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered* or *Threatened* under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

Burrowing owls are summer residents in Canada, breeding in the Mixedgrass and Dry Mixedgrass natural subregions of Alberta. They require an adequate nest burrow, usually situated in an open area of short grasses with enough permanent vegetative cover and tall grasses within their foraging range to provide a sufficient amount of prey. The quantity and quality of such grassland habitat has declined substantially on much of the Canadian prairie, along with increases in habitat fragmentation, pesticide use and predator populations, all of which may have negatively affected burrowing owl populations. Habitat modification has been least severe in Alberta, where large areas of potentially suitable habitat have been maintained to support livestock grazing rather than being converted to annual crops.

The breeding population in Alberta is currently estimated to be between 200 and 400 pairs, compared to estimates of approximately 800 pairs in 1997, 1000 pairs in 1990, and over 1500 pairs in 1978. The provincial range has also contracted significantly from its historical extent. Reports from rural landowners throughout the burrowing owl's range in southern Alberta have documented steady yearly declines in owl numbers, and systematic surveys on sites near Hanna and Brooks have provided evidence for this decline. Unfortunately, the exact causes of the population decrease are, as yet, unknown. Unless the population trend is reversed, the burrowing owl will be extirpated from the province, and from the entire country, within a few decades.

The burrowing owl is currently listed as a federally *Endangered* species in Canada under the *Species At Risk Act*, and is designated as *Threatened* under Alberta's *Wildlife Act*. This review of the status of the burrowing owl in Alberta was undertaken as a step in updating the provincial status of this species.

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INTRODUCTION

The burrowing owl (*Athene cunicularia*; previously called *Speotyto cunicularia*) is found throughout Mexico, the western United States and southwestern Canada (Haug et al. 1993). In the past few decades, there has been widespread national and international concern about sharp and continuing declines in populations of this species throughout Canada and the United States (Wellicome and Holroyd 2001). The majority of jurisdictions within the burrowing owl's range give it special status (Haug et al. 1993, Holroyd et al. 2001).

In Alberta, burrowing owls are classified as *Threatened** under the *Wildlife Act*, and they are listed as *Endangered* in Schedule 1 of the federal *Species At Risk Act*. This report summarizes current and historical information on the burrowing owl in Alberta, in an effort to update its provincial status.

HABITAT

1. Nesting Habitat – Specific habitat characteristics of burrowing owl nest sites vary with geographic location. Three general attributes of nesting habitat are available nest burrows, short (< 10 cm) or sparse vegetation, and open terrain (Zarn 1974). In Alberta, nests are found on flat to gently undulating, treeless plains in the Mixedgrass and Dry Mixedgrass subregions of the Grassland Natural Region (Alberta Natural Heritage Information Centre 2004a) in the southeastern portion of the province. In comparable ecoregions of Saskatchewan (Harris et al. 1983), grassland pastures (native or tame grass) are preferentially selected for nesting habitat, while crop fields are strongly avoided (Clayton and Schmutz 1999, Poulin et al. in review). Similarly, in Alberta, areas grazed by livestock currently provide the vast majority of nesting habitat for burrowing owls. Richardson's ground squirrel (*Spermophilus richardsonii*) or badger (*Taxidea taxus*) burrows, and rarely fox (*Vulpes* spp.) or coyote (*Canis latrans*) dens are used for nesting, roosting and caching food.

Schmutz (1997) compared microhabitat variables between occupied nest sites and unoccupied sites near Hanna, Alberta in 1989-1990. No significant difference was detected in the density of grasshoppers, number of badger or ground squirrel burrows within 500 m, or the extent of cultivation between the occupied and unoccupied sites, suggesting that nest site selection was not based on any of these habitat characteristics. However, on the moist mixed-grasslands of southern Saskatchewan, Poulin et al. (in review) found that nest burrows were surrounded by twice as many other burrows as were non-nest burrows within the same pasture. Similarly, James et al. (1991) found that owls appeared to select pastures that were more level, more likely to be grazed, and had a greater density of ground squirrel burrows than unoccupied pastures. Similar results have been reported from the United States (Plumpton and Lutz 1993a, Desmond and Savidge 1999).

The soil systems selected for nesting have not been examined in Alberta, but in Saskatchewan, most burrow sites examined by Harris and Lamont (1985) were located on lacustrine (fine-grained sediment originally deposited in still lake water), solonetzic (dense soil, high in clay and sodium), saline (high salt content) and alluvium (deep, stratified soil formed by deposition from rivers and streams) soil systems with few rocks. In particular, owl densities on lacustrine systems were five times higher than those in the second most highly selected category, solonetzic soils (Harris and Lamont 1985).

2. Foraging Habitat – Burrowing owls have different habitat requirements for foraging than they do for nesting. Small mammals (especially mice and voles) comprise the majority of the

* See Appendix 1 for definitions of selected status designations.

biomass of their diet during the nestling period (Schmutz et al. 1991a, Poulin 2003, Sissons 2003). In Alberta, owls tend to forage over areas of tall, dense vegetation such as low-lying ephemeral wetland areas (Sissons 2003). Similarly, Haug and Oliphant (1990) found that owls in Saskatchewan avoided cropland and heavily grazed pastures when foraging, preferring areas with dense, relatively tall (> 30 cm), permanent vegetation, such as uncultivated areas and roadside ditches. These habitats tend to support the highest densities of meadow voles (*Microtus pennsylvanicus*) compared with other habitats such as crop fields and heavily grazed pastures (Poulin 2003). Higher numbers of grasshoppers were also found in areas where litter depth was greatest (Sissons 2003), suggesting that owls are foraging in areas more likely to contain these prey species.

Foraging ranges for adult owls averaged 3.28 km^2 in Alberta (range = 0.34–7.56 km^2; Sissons 2003) and 2.41 km^2 in Saskatchewan (range = 0.14–4.81 km^2; Haug and Oliphant 1990). Therefore, in addition to requiring adequate nesting habitat, burrowing owls also require enough permanent cover and tall vegetation within their foraging range to supply a sufficient amount of small mammals and other prey. These habitat requirements are consistent with a healthy mosaic of grassland habitats.

3. Wintering Habitat – Recently, studies in Texas and Mexico have shown that habitat use during the winter is markedly different than during the breeding season. Owls were found roosting under weeds and orange trees, and in shrubland (G. Holroyd and H. Trefry unpubl. data). In Mexico, most of the roosts used by owls were animal burrows; small rock cliffs and vegetation were also used as roosts. In Texas, culverts comprised the majority of roosting sites; animal burrows, miscellaneous debris piles and vegetation were also used (G. Holroyd and H. Trefry pers. comm.).

4. Habitat Modification – Census data from Agriculture Canada show that tame and native pasture habitat within the burrowing owl's range in Alberta has declined considerably over the past quarter century. From 1966 to 1991, the amount of total farm area allocated as pasture within the owl's range (as defined in Wedgwood 1978) decreased by approximately 8% (664 330 ha). Telfer (1992) estimated that 39% of the native grasslands in prairie Canada were cultivated between 1949 and 1986. The most striking loss of grassland habitat occurred between 1976 and 1986, following a peak in wheat prices (Wellicome and Haug 1995). Currently, Alberta has 32% of its native prairie remaining, Saskatchewan 30% and Manitoba 23% (Canadian Prairie Partners in Flight 2004). However, only certain areas of grasslands are available to burrowing owls for nesting (e.g., areas of rocky soil, hilly terrain and lowland that occasionally floods are generally not inhabited by burrowing owls). The land and soil systems that burrowing owls select (such as flat land with few rocks) are also favoured for farming, and thus have undoubtedly declined and become fragmented faster than other areas of grassland. Even though the large-scale decline in available nesting habitat, and the associated increase in fragmentation, appear to have largely stopped, burrowing owl populations continue to decline (see "Limiting Factors" below).

CONSERVATION BIOLOGY

1. Species Description and Longevity – The burrowing owl is a small owl, weighing 125–235 g. Neither plumage nor size differs significantly between the sexes (Plumpton and Lutz 1994, T. Wellicome unpubl. data), although males can be slightly lighter coloured than females for much of the breeding season. The species' longevity in Alberta is not known; however, long-term studies in Saskatchewan have revealed no banded owls more than six years old (D. Todd, R. Poulin and T. Wellicome unpubl. data). The oldest wild owl known in

North America, based on banding returns, was nine years old (Klimkiewicz 2002), and the oldest known captive owl lived for 15 years in the Coaldale Birds of Prey Centre (D. Johnson pers. comm.).

2. Breeding Biology – Burrowing owls typically breed for the first time at 10 months of age (Haug et al. 1993). Mate selection biology is unknown. They typically arrive in Alberta between early April and the middle of May. Once a nest burrow is selected, the nest chamber and tunnel are lined with dried, shredded manure, or tufts of grass, twine or other materials. Males provide food to their mates before egg-laying and continue to do so throughout the breeding season; the female's hunting activity increases markedly when brooding of young is complete (Poulin 2003). Egg-laying begins between late April and late May. Clutch sizes typically range between 6 and 12 eggs (up to 14; Todd and Skilnick 2003), averaging 9 eggs in Saskatchewan (Wellicome 2000). Incubation lasts 28–30 days and hatching is asynchronous, resulting in an age disparity among the nestlings (Wellicome 2000). Hatchlings are altricial (immobile, with eyes closed and fed by the parents), and starvation and cannibalism often occur at the nestling stage during food shortages (Wellicome 2000). Owlets can appear at the entrance to their nest burrows as young as 10–12 days after hatching, begin walking to nearby burrows at approximately 15 days, and are capable of sustained flight by 40 days after hatching. Fledglings become independent between 60 and 70 days after hatching, but may remain at or near their natal site until migration (Todd 2001).

3. Diet and Foraging Behaviour – The burrowing owl is a generalist predator of small vertebrates and invertebrates (Plumpton and Lutz 1993b, Poulin 2003, Sissons 2003). In Canada, deer mice (*Peromyscus maniculatus*), meadow voles and sagebrush voles (*Lemmiscus curtatus*) constitute the majority (approximately 90%) of the diet by biomass (Schmutz et al. 1991a, Haug et al. 1993, Poulin 2003). Later in the season, grasshoppers and other insects become increasingly more prevalent in the diet (Haug et al. 1993, Poulin 2003, Sissons 2003). The relative importance of particular prey species is highly dependent on their availability in the environment, which can vary dramatically both within a breeding season and between years.

During the nestling phase (at least up to 30 days after hatching), there is a partitioning in foraging behaviour such that males deliver the majority of the vertebrate prey items, while females are responsible for the majority of the invertebrate prey deliveries (Poulin 2003). Vertebrate prey deliveries are highly concentrated around dusk and dawn, and the frequency of deliveries increases greatly once the eggs hatch. Invertebrate prey deliveries occur throughout the day and night but tend to be most common during the day. The rate of invertebrate deliveries increases sharply once the chicks are greater than 10 days old (Poulin 2003), corresponding to a time when insects become more active and abundant in the environment, and the female is freed from the majority of her brooding duties.

4. Potential Predators – There are two general types of burrowing owl predators: (1) those that destroy the entire brood by entering or digging up burrows and eating eggs, nestlings and/or adult females; and (2) those that prey on older nestlings and adults when they are above ground. In Alberta, animals that can potentially access nest chambers include badgers, foxes, striped skunks (*Mephitis mephitis*), and least weasel, ermine and long-tailed weasel (*Mustela nivalis, M. erminea* and *M. frenata*). Potential above-ground predators include coyotes, domestic cats (*Felis domesticus)* and dogs (*Canis familiaris*), Swainson's hawks (*Buteo swainsoni*), ferruginous hawks (*B. regalis*), red-tailed hawks (*B. jamaicensis*), great horned owls (*Bubo virginianus*), northern harriers (*Circus cyaneus*), short-eared owls (*Asio flammeus*) and prairie falcons (*Falco mexicanus*).

5. Nesting Success and Survival – Across the Alberta breeding range, 80% (36 of 45) of nests that were monitored throughout the nesting period in 2004 successfully fledged young (however, true nesting success calculated by daily survival rates is likely lower, since monitoring did not start at nest initiation for all nests; T. Wellicome unpubl. data). Eleven percent (5 of 45) of nests were predated, 4% (2 of 45) failed because of burrow flooding, and 4% (2 of 45) failed for unknown reasons (T. Wellicome unpubl. data). As a cursory comparison, across the entire breeding range in the prairies (Saskatchewan and Alberta), nesting success rates were: 85% of the nests in 2003 and 86% in 2004 had successfully fledged young (T. Wellicome unpubl. data). Most failures were attributed to predation, which accounted for approximately 6% of all monitored nests in each year. Badgers were the main nest predator—others included snakes, foxes, coyotes or raptors (killing an adult, resulting in nest failure). The remaining failures were caused by human activities (crop cultivation and road construction) or food shortages associated with cold, wet weather (T. Wellicome unpubl. data). However, nesting success can be highly variable: in 1995, 53% (10 of 19) of nests in natural burrows within a 12 200 km^2 study area of southern Saskatchewan (encompassing roughly 6% of the Canadian range) failed because of nest predators (mainly badgers; Wellicome et al. 1997).

Data on adult survival during the breeding season (from spring arrival to fledging) are somewhat limited. In Alberta, Sissons (2003) reported 83% adult male survival in 1998–1999 based on radio-telemetry of 17 owls, while Clayton and Schmutz (1999) reported adult survival of only 48% for males ($n = 11$; n is the initial sample size here and elsewhere in the report where similar statistics are reported) and 62% for females ($n = 12$). In Saskatchewan, female survival (based on sightings during repeated nest visits between 1992 and 1998) ranged from 88% to 100%; male survival during the same period ranged from 94% to 100% (T. Wellicome unpubl. data). Avian predators caused all male mortality, while all but four female mortalities resulted from predation by badgers, skunks or weasels (the other mortalities were caused by humans (collision with a vehicle and cultivation) and starvation or disease; T. Wellicome unpubl. data). Clayton and Schmutz (1999) reported 100% survival of adult females in Saskatchewan, but only 38% survival of adult males (although these estimates were based on only two radio-tagged females and five males). Adult annual survival based on resighting of banded birds within specific study areas has been estimated at 51% (Hoyt et al. 2001), although this technique cannot account for emigration between years.

Juvenile survival during the post-fledging period (from fledging to migration; roughly three months) has been documented more closely in telemetry studies. In Alberta, survival ranged from 45% during 1995–1996 ($n = 21$; Clayton and Schmutz 1999) to 61% during 1999–2000 ($n = 52$; D. Shyry unpubl. data). Studies in Saskatchewan show that juvenile survival varies to a certain extent with food availability. Todd et al. (2003) reported average post-fledging juvenile survival of 55% ($n = 64$) between 1998 and 2000 (years of apparently "normal" food availability). Juvenile survival was significantly ($p = 0.02$) higher in 1997 (100%; $n = 12$), and may have been related to the unusually high abundance of voles that occurred that year (Todd et al. 2003). From all accounts, most post-fledging mortality occurs shortly (i.e., within two weeks) after fledging, and is mainly attributable to avian predators and anthropogenic factors. Annual juvenile survival, based on banding returns in the Regina Plain study area in Saskatchewan has been estimated at 6% (Hoyt et al. 2001); however, this estimate does not take into account the considerable dispersal that occurs during natal dispersal (see Dispersal below).

6. Dispersal – Recent evidence from stable isotope analysis of feather samples collected throughout the burrowing owl's North American range suggests that dispersal is occurring on a vast scale, resulting in potential genetic exchange throughout the owl's entire range (Duxbury 2004). Breeding and natal dispersal have not been studied extensively in Alberta; however, a limited number of banded owl sightings near Brooks suggests that natal dispersal (the distance between where an owl was hatched and where it settled to breed for the first time) occurs at a scale much greater than breeding dispersal (the distance between successive breeding locations for adults). First-year birds ($n = 6$) nested 2–25 km from their natal burrows, whereas adults ($n = 5$) returned to breed only 0.02–0.7 km from their previous nest site (D. Shyry unpubl. data). Recent stable isotope analysis of feathers taken from owls nesting in Alberta suggested that 43% (23 of 53) returned to the same general area as they had occupied the previous summer (Duxbury 2004), although this analysis did not differentiate between age or sex.

In Saskatchewan, information from banded bird re-sightings within a 12 200 km^2 study area suggests that philopatry (the tendency to return to breeding grounds) among breeding birds is 2.6 times higher for adult males (47% return rate; 32 of 68) than females (18%, 31 of 171) and 2 times higher for first-year males (5.3%, 48 of 899) than first-year females (2.6%, 23 of 899; R. Poulin, D. Todd and T. Wellicome unpubl. data). The majority (approximately 80%) of the males that did return to the study area returned to the same general location (within 10 km), or even the same burrow, that they had occupied in the previous year (R. Poulin, D. Todd and T. Wellicome unpubl. data). However, these data also suggest that dispersal is occurring over a considerable area: up to 37% of adult females, 10% of adult males, 71% of first-year females and 45% of first-year males had between-year dispersal distances greater than could be detected within the boundaries of the 12 200 km^2 study area (i.e., the owls were predicted to be alive but residing outside of the study area; R. Poulin, D. Todd and T. Wellicome unpubl. data, based on methodologies described in Baker 1995). These results are consistent with those reported by Stepnisky (2001), who compiled banding return data from study areas in Alberta, Saskatchewan and Manitoba between 1986 and 1997. In general, females tended to disperse farther than males (median natal dispersal: females = 13.3 km; males = 6.9 km; median breeding dispersal: females = 0.5 km; males = 0.3 km), and adults showed considerably higher fidelity than juveniles (median juvenile dispersal = 10 km, median adult dispersal = 0.4 km).

DISTRIBUTION

1. Alberta – Burrowing owls are distributed sparsely throughout the Mixedgrass and Dry Mixedgrass natural subregions of Alberta (Alberta Natural Heritage Information Centre 2004a). Historically, they were also somewhat common in the Northern Fescue Subregion and the southern part of the Central Parkland Subregion, as far north as Wainwright (Wedgwood 1978), but their range has since contracted. According to information published in Wellicome and Holroyd (2001), burrowing owls once (circa 1970s) inhabited an area of approximately 103 500 km^2 in Alberta. Currently, their range in Alberta spans from the Saskatchewan border west to Milk River, Warner and just east of Lethbridge, north to Drumheller, Hanna and Oyen (Figure 1). Based on this distribution, the extent of occurrence for burrowing owls in Alberta is approximately 57 500 km^2, which accounts for roughly 35% of the current Canadian range and 1.5% of the North American range. Within that distribution, the area of occupancy based on 2004 nest locations is 316 km^2. The current range in Alberta represents a loss of approximately 44% (46 000 km^2) in approximately 30 years.

2. Other Areas – Throughout North America, burrowing owls are found in open, well-drained

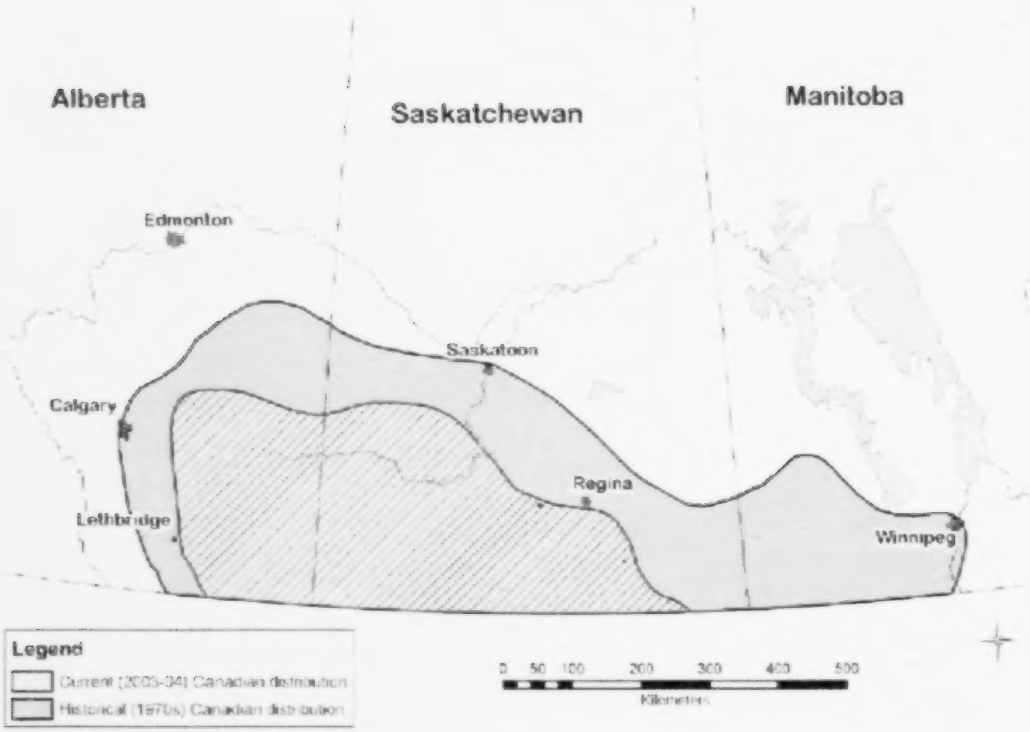

Figure 1. Historical (1970s) and reduced current (2003-04) distribution of the burrowing owl in Canada. The 1970s distribution was based on Wedgwood (1978). The 2004 distribution was constructed using biologists' extensive nest searches throughout Alberta and Saskatchewan, Operation Grassland Community (AB) and Operation Burrowing Owl (SK) landowner reports, Biodiversity Species Observation Database (AB), standardized surveys, landowner reports and incidental sightings.

grasslands, steppes, deserts, prairies and agricultural lands (Haug et al. 1993). The distribution has contracted considerably over the last quarter century, particularly on the northern and eastern periphery (Figure 2). In Canada during the 1970s, burrowing owls were found as far north as Saskatoon and Yorkton in Saskatchewan, and as far east as Winnipeg, Manitoba. Currently, they are seldom found north of Kindersley, Regina and Weyburn, or east of Estevan, Saskatchewan. There have been no known burrowing owls nesting in Manitoba since 1999 (K. De Smet pers. comm.). Historically, burrowing owls were also common in the grasslands of the southern interior of British Columbia, but were extirpated from British Columbia by 1980 (Leupin and Low 2001). In the United States, burrowing owls have been extirpated from Minnesota and Iowa, and their range is contracting eastward throughout the remaining portion of their range (Figure 2).

The winter distribution of the Canadian burrowing owl population is not known completely, although recent banding projects and stable isotope studies (see "Recent Management in Alberta") have confirmed that owls from Alberta and Saskatchewan winter in southern Texas and areas of central Mexico (G. Holroyd and H. Trefry unpubl. data). Owls from British Columbia (where owls have been re-introduced since 1983 but are not yet re-established) migrate south along the west coast, wintering in areas between Washington and central California; however, a small number of owls has been reported overwintering in the Lower Mainland of British Columbia, at the southern end of Vancouver Island (Howie 1980) and near Kamloops (J. Surgenor pers. comm.).

The distribution of the burrowing owl in Mexico is not well known, but preliminary surveys and a review of museum specimens showed that its major breeding range is in the northern states of Chihuahua and Coahuila, and wintering range is in the coastal states of Tamaulipas and Veracruz along the Gulf of Mexico, and west to Colima in central Mexico (G. Holroyd pers. comm.). Historically, there have been reports of burrowing owls far south as southern Mexico and Guatemala, but these have been only sporadic and no breeding records are known for these areas.

POPULATION SIZE AND TRENDS

1. Alberta – In Alberta, two areas have been surveyed specifically for burrowing owls since the early 1990s as part of a provincial monitoring program. The Hanna trend blocks (H-blocks) were established in 1991, and consist of 109 quarter sections (70.6 km^2 total area) of pasture and cultivated land near the town of Hanna. Complete or partial standardized surveys have been carried out in the H-blocks for 8 of the past 14 years (Scobie and Russell 2000, Shyry et al. 2001, Scobie 2002, Kissner and Skiftun 2004) and show a significant decline in the number of burrowing owls inhabiting the area (Figure 3). In 2003, only one owl nest was found (Kissner and Skiftun 2004). Currently, the density of active owl nests in the area is extremely low, at approximately 1 nest/100 km^2. This is a substantial decline from the approximately 30 nests/100 km^2 that were found in that same area when surveys began in 1991 (Shyry 1999). Between 1994 and 2003 (the most recent 10 years of data), there has been a significant 10-year decline of 94% in the Hanna trend blocks (linear regression, $r^2 = 0.74$, $n = 7$, $p = 0.013$).

The second standardized survey area in Alberta (K-blocks) was established in 1993, and consists of 160 quarter sections (103.6 km^2 total area) located in the Eastern Irrigation District, near the town of Brooks. The K-blocks have been surveyed for 10 of the past 12 years (Shyry et al. 2001, Russell 2002, D. Shyry unpubl. data). Nest density has declined continually since 1997, when it reached a peak of 13.5 nests/100 km^2 (Figure 4). In 2004, nest density was only 4.8 nests/100 km^2, which represented only 4 nests in the entire Brooks trend block area (D. Shyry

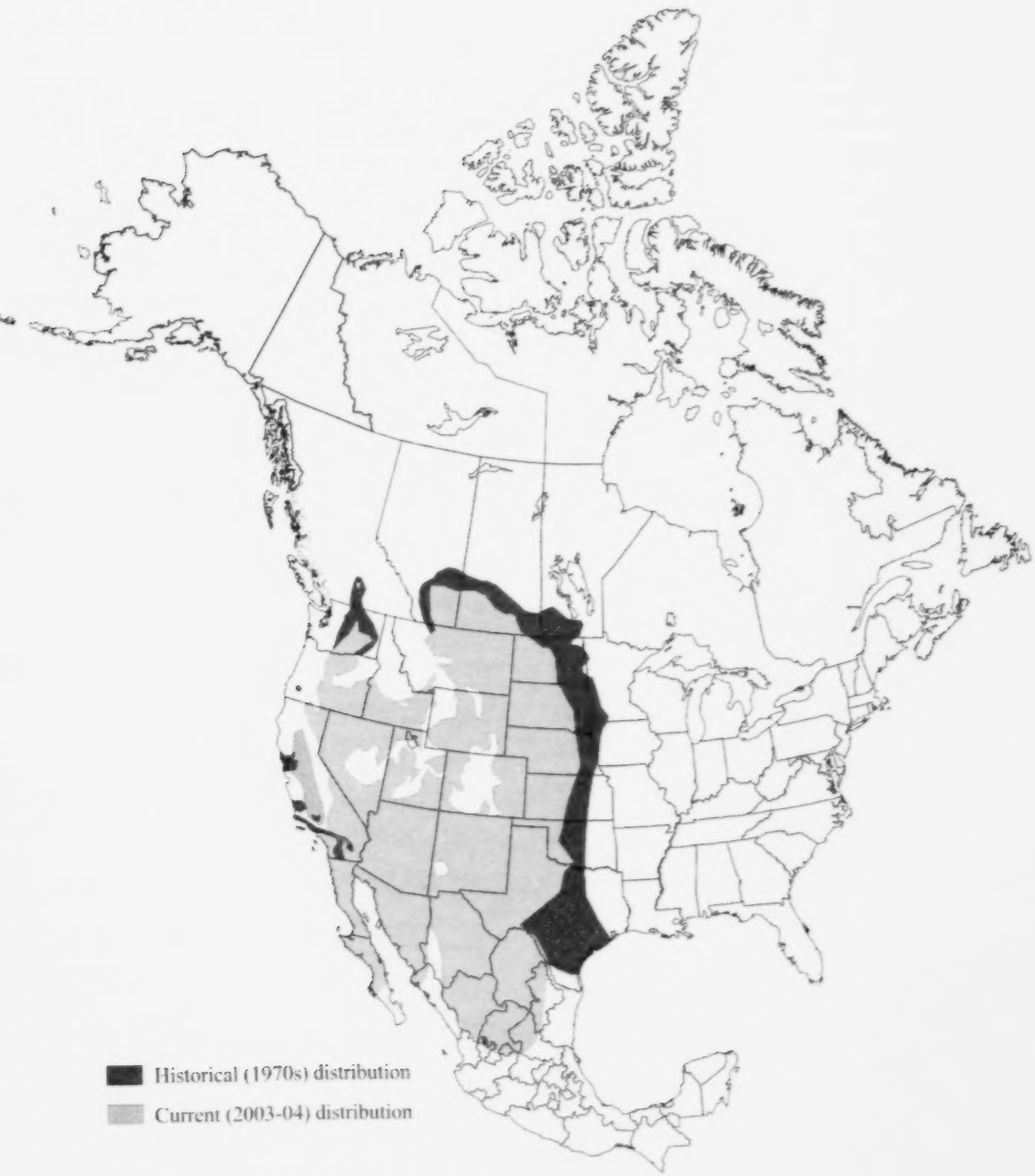

Figure 2. Historical and reduced current distribution of the burrowing owl in North America (Modified from Wellicome and Holroyd 2001). Range contractions have been occurring from the north and east; the owls are now extirpated from Iowa and Minnesota, and are only rarely found in Manitoba and British Columbia.

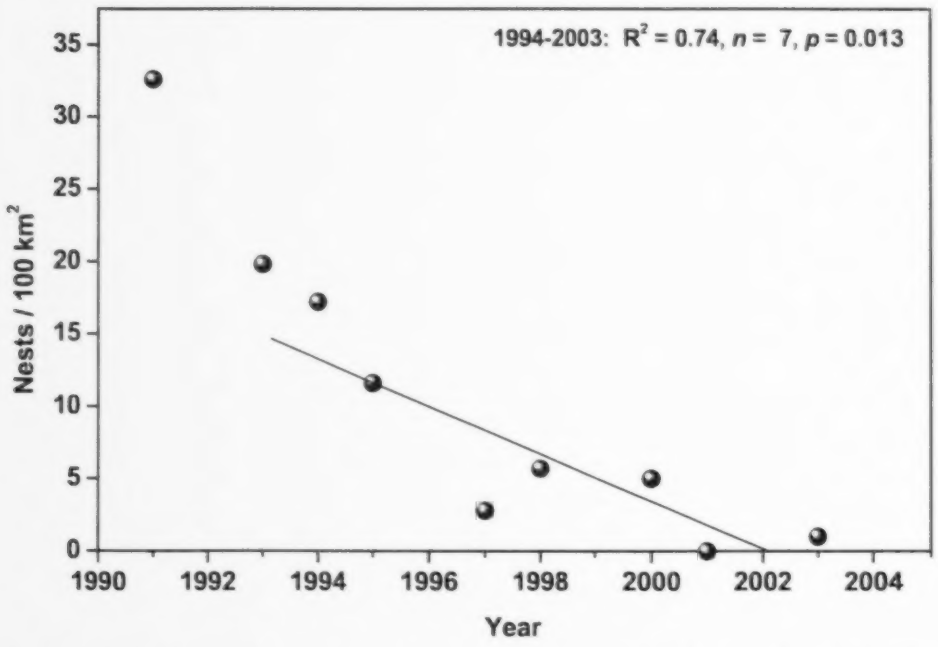

Figure 3. Density of burrowing owl nests in the Hanna trend blocks, showing a significant decline of 94% (linear regression; $r^2 = 0.74$, $n = 7$, $p = 0.013$) in the past 10 years (1994–2003). (Modified from Scobie 2002, and Kissner and Skiftun 2004).

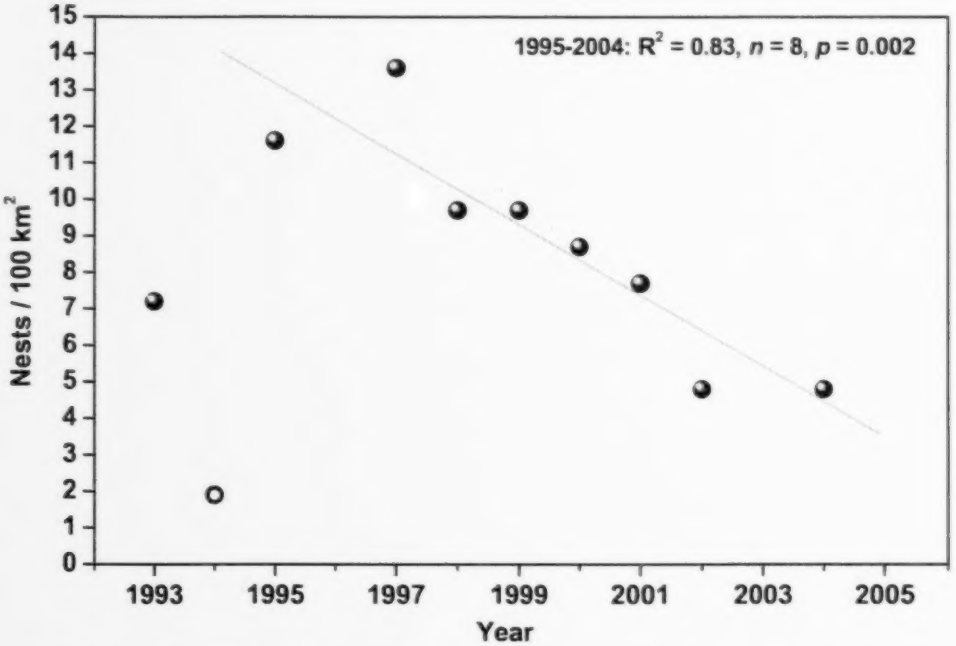

Figure 4. Density of burrowing owl nests in the Brooks trend blocks, showing a significant decline of 58% (linear regression; $r^2 = 0.83$, $n = 8$, $p = 0.002$) in the past 10 years (1995–2004). Note that a complete survey was not carried out in 1994 (open circle), and is not comparable to other years. (Modified from Russell 2002, with additional data provided by D. Shyry).

unpubl. data). Using data from the past 10 years (1995–2004), there has been a significant 10-year decline of 58% in the K-blocks (linear regression, $r^2 = 0.83$, $n = 8$ $p = 0.002$).

Although the trend block surveys are the most consistent way of determining changes in population size between years, the survey areas encompass only a small fraction of the owl's range in Alberta. In recent years, standardized surveys have also been carried out over a larger area of the province, and show similarly low densities on native grassland, and declines in density reflecting the densities in the two trend blocks (G. Holroyd, unpubl. data, D. Scobie, unpubl. data).

The most extensive quantitative data for gauging changes in the provincial population are provided by Operation Grassland Community (OGC). This private land-stewardship program relies on rural landowners across southern Alberta to report the number of pairs nesting on their property on an annual basis. Such data are useful for estimating population trends at a large scale (refer to Wellicome and Haug 1995 for discussion). In 2004, a total of 208 OGC members reported 53 owl pairs on more than 1700 km^2 of grassland (L. Tomyn pers. comm.). The average number of pairs reported per member has declined by 88% since the program's inception in 1989 (Figure 5), and by 30% in the past 10 years.

Long-term analysis from the North American Breeding Bird Survey (BBS) indicates a decline in Alberta of 11.2% per year ($n = 5$ routes, $p = 0.08$) between 1966 and 2003 (Sauer et al. 2004), although the accuracy of these trends are limited by small sample sizes (Sauer et al. 2004), and a methodology that is not necessarily appropriate for detecting burrowing owls.

At Canadian Forces Base, Suffield, a minimum 26 and 17 confirmed nests were reported by a Canadian Wildlife Service inventory during 1994 and 1995, respectively (B. Smith, pers. comm.). In 2004, there were only five active nests found at Suffield (T. Wellicome, unpubl. data).

In 1978, the population of burrowing owls in Alberta was estimated at more than 1500 pairs (Wellicome and Haug 1995). By 1990, the population had declined to an estimated 1000 pairs (Haug and Didiuk 1991), and to fewer than 800 pairs in 1997 (Wellicome 1997). If one extrapolates the current density of burrowing owls found in the two trend blocks (1 per 100 km^2 in the H-blocks and 4.8 per 100 km^2 in the K-blocks) across the grassland encompassed by the current burrowing owl range in Alberta (32 036 km^2), there could be between 320 and 1538 burrowing owl nests in the province, although the higher estimate is likely unreasonable since it exceeds even the 1978 population estimate. If we assume that the previous population estimates were accurate, the rate of decline in the past 10 years as estimated by the standardized surveys of the H-Blocks (94%) and K-Blocks (58%) leaves an estimated Alberta population of 51 or 360 pairs, respectively. The most recent and extensive population count was conducted in 2004, based on a combination of the standardized trend block surveys, OGC data, biologists studying owls across Alberta, reports and incidental sightings. By all accounts, the burrowing owl population in Canada increased in 2004 by 17–73% over the previous year (National Burrowing Owl Recovery Team 2004), yet only 288 individuals (approximately 144 pairs) were known in Alberta in 2004 (National Burrowing Owl Recovery Team Meeting 2004). While this number likely underestimates the total number of owls in the province, there is no reason to believe that the true value would substantially exceed an upper estimate of 360 pairs. Therefore, the burrowing owl population in Alberta in 2004 was likely between 200 pairs (a round estimate based on the fact that 144 pairs were found) and 400 pairs (based on previous population estimates and known population decline) (400–800 individuals). This represents a 73–87% decline from the 1978 estimate, a 60%–

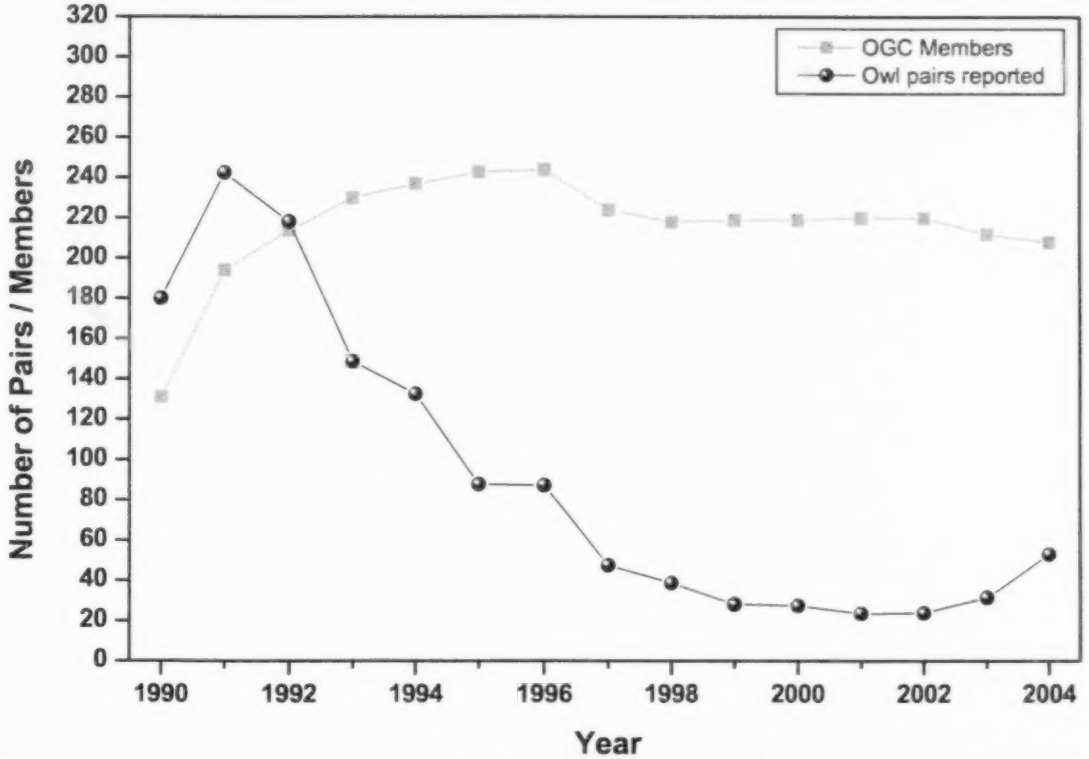

Figure 5. Number of owl pairs reported by Operation Grassland Community members in Alberta, showing a sharp decline (89%) between 1992 and 2002 despite relatively constant membership. Unpublished data provided by L. Tomyn, Operation Grassland Community.

80% decline from the 1990 estimate, and a 50–75% decline since 1997.

2. Other Areas – Operation Burrowing Owl (OBO) is a prairie stewardship program in Saskatchewan that is similar to Operation Grassland Community in Alberta. In 2000, a total of 459 OBO members across prairie Saskatchewan reported 54 pairs of owls: a significant decline from the 681 pairs reported by 352 OBO members in 1988 (Skeel et al. 2001). Correcting for non-reporting members, this represents a 95% decline in the burrowing owl population in Saskatchewan in 13 years (1988–2000). Similar long-term data have been collected by biologists in the Regina Plain area of south-central Saskatchewan. In a portion of the study area surveyed each year since 1987, the number of owl pairs declined from 78 pairs to only 2 pairs; a 97% decline in 17 years (P. James, T. Wellicome, D. Todd, R. Poulin, unpubl. data).

In Manitoba, burrowing owl population declines were evident as early as the 1920s (De Smet 1997). Wedgwood (1978) estimated approximately 110 pairs of owls breeding in the province in the mid-1970s. By 1982, Ratcliff (1987) reported only 76 pairs, and only three pairs were reported in 1999 (K. De Smet pers. comm.). Burrowing owls appear to have been extirpated from Manitoba since 2000 (K. De Smet pers. comm.). A captive release program was attempted in that province, but was discontinued in 1996 when it was apparent the releases were ineffective at halting the population decline (De Smet 1997).

In British Columbia, burrowing owls were extirpated from the province by the early 1980s (Leupin and Low 2001). Various relocation and release efforts were attempted as early as 1983 (Dyer 1991), with captive breeding and reintroductions initiated in 1989 (Leupin and

Low 2001). Captive-bred owls are still released each year near Kamloops, British Columbia, but so far these recovery efforts have not resulted in the re-establishment of a viable population, with only a handful of owls returning each year (J. Surgenor pers. comm.).

When the burrowing owl was listed as *Threatened* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1979, its population in Canada likely exceeded 3000 pairs and was declining (Wedgwood 1978, Wellicome and Haug 1995). As of 1990, the declining prairie population was estimated at roughly 2500 pairs (Haug and Didiuk 1991). In 1995, the Canadian population was estimated to be between 1010 and 1685 pairs (Wellicome and Haug 1995). The most recent information suggests a minimum number of 805 individuals (roughly 400 pairs) in Canada in 2004 (National Burrowing Owl Recovery Team 2004). Although this number probably underestimates the true population, it is unlikely that there were more than 600–800 pairs (1200–1600 individuals) left in Canada in 2004.

Even though population estimates and trends in some areas are difficult to determine because of a lack of historical information or a scarcity of nesting pairs, there is strong evidence for a continual decline in burrowing owl populations across North America (Sheffield 1997, Wellicome and Holroyd 2001, Klute et al. 2003). Of 19 state wildlife agencies polled in the United States in the early 1990s, nine reported decreases in their owl populations, and none reported increases (James and Espie 1997). The educated guesses collected from this poll suggested between 17 000 and 82 000 breeding pairs of burrowing owls in the United States in 1992. Long-term population trend analysis from the BBS (1966-2003) shows a significant Canadian decline of 13.2% per year ($n = 7$ routes, $p = 0.02$), and a continental decline of 1.2% per year ($n = 310$ routes, $p = 0.62$; Sauer et al. 2004), although these trends are limited by deficiencies such as small sample sizes (regional abundance of less than 0.1 birds per route; Sauer et al. 2004) and inappropriate methodologies for detecting Burrowing Owls. State surveys in the United States show declines in California (12%–27% between 1986 and 1991; DeSante et al. 1997), Minnesota (no nests reported between 1992 and 1998; Martell et al. 2001), Nebraska (58% between 1990 and 1996; Desmond et al. 2000), New Mexico (mixed trends, depending on habitat loss; Arrowood et al. 2001), North Dakota (sharp decline in the eastern third of the state during the past 5–15 years; Murphy et al. 2001), Oklahoma (estimated 800–1000 owls, restricted mainly to the panhandle; Sheffield and Howery 2001), Nevada (local declines with urban habitat loss; Alcorn 1988), Texas (low overall number of owls, non-significant decline in breeding birds; significant decline in wintering birds; McIntyre 2004) and Washington (serious decline in most areas, Klute et al. 2003).

LIMITING FACTORS

Despite the considerable research that has occurred in the last 30 years, no single factor has been confirmed to be solely responsible for the burrowing owl population decline. The threats are likely cumulative, and from a variety of sources – both anthropogenic and ecological. The following factors are all thought to contribute at least to a certain degree to the burrowing owl's population decline.

1. Habitat Loss, Fragmentation and Degradation – Over most of the North American range of burrowing owls, the loss and degradation of suitable nesting and foraging habitat is cited as being the single most important threat to their persistence, either through a reduction of burrowing mammals such as prairie dogs, or through the conversion of native grassland to agricultural crop fields (Sheffield 1997, McDonald et al. 2004). The loss of habitat may affect the owls directly, by reducing the number and availability of suitable nesting

burrows, or indirectly, by reducing the prey base or increasing the risk of predation as a result of higher, more concentrated predator populations (Wilcove et al. 1986, Sheffield 1997, Clayton and Schmutz 1999, Poulin 2003). While the loss of > 90% of prairie dogs (*Cynomys* spp.) in the United States in the past century (Miller et al. 1994, Sheffield 1997) undoubtedly affects owls that migrate through, and winter in the United States and Mexico, the alteration of the native landscape as a result of massive agricultural development and urban sprawl represents the most pressing habitat-related threat to burrowing owls in Canada.

The potential effects of habitat fragmentation on juvenile burrowing owls have been documented. Clayton (1997) compared juvenile dispersal behaviours between extensively cultivated areas in southern Saskatchewan (> 90% cultivation) and more contiguous grassland areas in Alberta (< 20% cultivation). Fledglings from the more contiguous grasslands of Alberta dispersed significantly earlier, moved more frequently, and traveled farther from their nest than did fledglings from crop-dominated areas in Saskatchewan, suggesting that fragmentation may have been affecting the juveniles' ability to disperse. Todd (2001) found similar trends in grassland patches within the agricultural matrix in Saskatchewan, reporting that juveniles from larger grassland patches tended to move more often and ultimately farther from their nest prior to migration than did those juveniles from smaller, more isolated patches. In addition, Todd (2001) reported a trend toward higher survival in the larger grassland patches.

Habitat fragmentation and intensive agricultural development may also be affecting burrowing owls indirectly by altering the distribution and/or abundance of their prey. Poulin (2003) speculated that the crop-dominated landscape in southern Saskatchewan may be affecting the ability of certain prey species (specifically, meadow voles) to reach peaks in populations (or irruptions) by restricting their dispersal and removing vole-preferred habitat (native grasslands, wetlands and other areas with substantial litter accumulation). Poulin (2003) further speculated that the reproductive strategy of the burrowing owl may be geared toward relying to a certain extent on these prey population peaks, and that when they cease the owl population is affected accordingly.

2. First Year Survival and Return to Breeding Grounds – In March 2003, biologists from Canada and the United States held a workshop in Canmore, Alberta, to discuss the current state of knowledge of burrowing owl biology and demographics related to proximate causes of the population decline. At the conclusion of the workshop, one of the most important factors thought to be contributing to the decline of burrowing owls in Canada was related to the first-year survival and dispersal of juveniles, from the nestling stage through to their prospective return to the breeding grounds the following spring. Sensitivity analysis of a population model generated from a long-term dataset in Saskatchewan also indicated that changes in survival from egg to first migration would have the greatest effect on population growth (B. St. Clair unpubl. data).

Between 1992 and 1998, Wellicome (2000) conducted a productivity enhancement project in a 12 200 km^2 study area in southern Saskatchewan, and found that the number of fledglings produced increased significantly when pairs were provided with supplemental food and protected inside predator-proof artificial nest burrows during the nesting period. In fact, over a nine-year period, productivity enhancement resulted in more than twice the number of fledglings being produced per pair (average = 5.1) compared to eight years before the experiment (average = 2.5) (T. Wellicome, D. Todd and R. Poulin unpubl. data). However, even with the significant increase in productivity, the local population decline was not reversed, suggesting that 1) food limitation may be a factor beyond the nestling stage alone, and 2) the burrowing owl population functions at a size

much larger than that encompassed by the study area.

3. Differential Immigration and Emigration – Another potentially important limiting factor may be differential immigration and emigration between the Canadian prairies and the United States. Duxbury (2004) performed stable isotope analysis on feather samples collected throughout North America, and from his results, speculated that there may be a net loss of Canadian owls to the United States because of an imbalance in the immigration and emigration rates between the U.S. and Canada. However, with this technique it is impossible to determine whether this potential imbalance results from an unnaturally high emigration from Canada or low immigration from the United States. This hypothesis requires further investigation; however, if this is the case, then factors affecting owls breeding in the United States could have a greater effect on owls breeding in Canada than was previously thought.

4. Mortality on Migration or Wintering Grounds – Mortality during migration and over the winter is exceptionally difficult to measure in long-distant migrants with variable fidelity to their nest sites. Currently, there are no estimates of survival for burrowing owls during migration. Recently, however, overwinter survival was studied in southern Texas and northern Mexico using radio-telemetry. Overwinter survival estimates for Mexico were about 80% (n=19 tagged owls), whereas survival in Texas was approximately 65% (n = 9; G. Holroyd and H. Trefry unpubl. data). Of the known mortalities, three were caused by raptors and one was due to anthropogenic causes.

5. Pesticide Application – No research has been conducted in Alberta to investigate the direct effects of pesticides on breeding burrowing owls; however, there is evidence to suggest that indirect effects may be occurring at some level. Invertebrate prey availability is significantly lowered immediately following the application of carbofuran (Anonymous 1993). In addition, survival of tagged deer mice and meadow voles in grassland sprayed for grasshopper control was 40% and 33% lower, respectively, than that of unsprayed populations (Brusnyk and Westworth 1987). In Saskatchewan, the application of carbofuran within 50 m of burrowing owl nests was associated with a 54% reduction in the number of young per nest and a 50% reduction in the proportion of pairs raising one or more young relative to controls (James and Fox 1987). The application of granular carbofuran was banned in Canada in 1999.

Even though DDT (dichlorodiphenyltrichloroethane) has been banned in Canada since 1971 and the United States since 1972, 5 of 11 owl carcasses in Saskatchewan in 1982 and 1983 were found to contain low levels (0.04 to 0.40 ppm) of its breakdown products, DDE (dichlorodiphenyldichloroethylene) and DDD (dichlorodiphenyldichloroethane) (Haug 1985). One of the five showing DDE also contained low levels of DDT (0.02 ppm). Presumably, the bird showing traces of DDT was an adult that picked up the pesticide in Mexico during the winter (the use of DDT was not banned in Mexico until 2000).

In southern Saskatchewan, there was a suggestion that both the number of successful nests and the number of young produced may have been lower in pastures where Richardson's ground squirrels were controlled with strychnine compared to untreated pastures (James et al. 1990). The poisoning of ground squirrels or prairie dogs would indirectly affect burrowing owls by reducing or eliminating quality nesting sites (burrows) over time.

6. Predation – Agricultural practices and the increased number of trees in the prairies as a result of fire suppression and planting have increased potential nesting habitat for large raptor species (i.e., great horned owls, Wellicome and Haug 1995; red-tailed hawks, Houston and Bechard 1983; Swainson's hawks, Schmutz

1987, 1989a), allowing their populations to increase. Avian predation was found to be the dominant cause of mortality for juvenile burrowing owls during the post-fledging period in both Alberta (30% during 1995-1996, Clayton and Schmutz 1999; 14.6% during 1999–2000, Shyry and Todd 2000) and Saskatchewan (20% during 1997–2000, Todd et al. 2003). Adult mortality attributable to avian predation was 52% for males and 23% for females in Alberta during 1994–1996 (Clayton and Schmutz 1999). The extirpation of wolves (*Canis lupus*) from the prairies has also encouraged increases in many mammalian predator populations (Sargeant et al. 1993): red fox (*Vulpes vulpes*), coyote and striped skunk populations have grown considerably from historic times (Rosatte 1987, Voigt 1987, Voigt and Berg 1987), despite persecution by humans. One can assume that predation pressure on burrowing owls by large raptors and mammalian predators has increased with the increasing populations of these predators on the prairies; however, without comparable survival data from historical times, it is impossible to determine the extent to which this may have occurred.

7. Collisions with Vehicles – In telemetry studies near Hanna and Brooks, between 0 and 4.1% of radio-tagged owls were killed by vehicle collisions (Clayton and Schmutz 1999, Shyry and Todd 2000). Collisions with vehicles appear to be more frequent in areas where highways and grid roads are more numerous. In Saskatchewan, Clayton (1997) found that 17% of radio-tagged fledglings and 18% of radio-tagged adult males were killed by vehicle collisions between 1995 and 1996. However, it should be noted that all of these mortalities occurred on grid roads near a single farm. In this same study area, less than 0.5 % of owls without transmitters were found or reported dead on roads each year from 1992 to 1996 (T. Wellicome unpubl. data), and less than 9% of radio-tagged juveniles were killed by vehicles between 1997 and 2000 (Todd et al. 2003).

8. Shooting – At a distance, burrowing owls can easily be mistaken for ground squirrels, and consequently, some owls are likely shot accidentally each year (Hjertaas et al. 1995). Although shooting mortality likely has little effect on the owl population as a whole, shooting burrowing mammals may also indirectly affect burrowing owls, by lowering the availability of burrows.

STATUS DESIGNATIONS*

1. Alberta – Historically, the burrowing owl was classified as an *Endangered* animal in Alberta under the *Wildlife Act* (1987). The species was included on Alberta's Red List in 1991 (Alberta Fish and Wildlife 1991), and again in 1996 (Alberta Wildlife Management Division 1996), indicating that its provincial population was in danger of declining to the point of becoming nonviable. The reasons given for this listing were the dramatic declines in the provincial and national populations, continued cultivation of nest sites, loss of ground squirrels, and pesticide use. In 1997, the *Endangered* list was subdivided into *Endangered* and *Threatened*, at which time the burrowing owl was placed in the *Threatened* category. In 1999, Alberta's Endangered Species Conservation Committee (ESCC) evaluated burrowing owls using World Conservation Union (IUCN) Red List criteria for the first time, and upheld the *Threatened* designation in Alberta.

Currently, the burrowing owl is classified as *Threatened* under Alberta's *Wildlife Act*, and *At Risk* according to *The General Status of Alberta Wild Species 2000* (Alberta Sustainable Resource Development 2001). The Alberta Natural Heritage Information Centre lists burrowing owls as S2B in Alberta (Alberta Natural Heritage Information Centre 2004b).

2. Other Areas – In 1979, burrowing owls were declared *Threatened* in Canada (Wedgwood 1978). This status was upheld in 1991 (Haug

* See Appendix 1 for definitions of selected status designations.

and Didiuk 1991), and subsequently uplisted to *Endangered* in 1995 (Wellicome and Haug 1995; COSEWIC 2004) recognizing continued, severe population declines. Burrowing owls are currently considered *At Risk* in British Columbia, Saskatchewan and Manitoba, according to *Wild Species 2000: The General Status of Species in Canada* (CESCC 2001). According to NatureServe (2004), the species is ranked G4 globally, recognizing its widespread distribution in North America, N2B nationally, S2B in Saskatchewan and S1B in British Columbia and Manitoba. Burrowing owls are also considered a priority species by the Prairie Habitat Joint Venture's Landbird Conservation Plan (Canadian Prairie Partners in Flight 2004).

In the United States, the burrowing owl was listed on the Audubon Society's Blue List in 1972, and was given *Special Concern* status in 1982 and 1986 (James and Ethier 1989). In 1994, the species was designated as a Category 2 species (for consideration of listing as a *Threatened* or *Endangered* species) by the U.S. Fish and Wildlife Service; however, this designation was discontinued in 1996. Currently, the burrowing owl is listed as a "National Bird of Conservation Concern" (U.S. Fish and Wildlife Service 2002), although it has no legal status in the United States and its Natural Heritage status is N4 or "apparently secure" (Klute et al. 2003; NatureServe 2004). It is listed as *Endangered* in Minnesota, *Threatened* in Colorado, and a *Species of Concern* in California, Montana, Oklahoma, Oregon, Utah, Washington and Wyoming (Klute et al. 2003). The species has no legal status in the nine other states within its range.

In Mexico, the burrowing owl was listed as nationally *Threatened* in 1994 (Diario Oficial de la Federación 1994).

RECENT MANAGEMENT IN ALBERTA

1. Habitat Securement, Protection and Enhancement – Since 1989, the Operation Grassland Community program has enlisted farmers, ranchers and other rural landowners in southern Alberta as volunteers in the protection of active and previously active burrowing owl nesting areas. Participating landowners sign a voluntary agreement to preserve nesting sites for five years, at which time the agreement may be renewed. As of 2004, a total of 283 OGC members was protecting more than 1700 km^2 of grassland habitat in Alberta (L. Tomyn pers. comm.). Suggestions for habitat preservation or improvement are provided in annual newsletters mailed to all members, and recently, habitat management plans specific to burrowing owls on individual properties have been provided to selected landowners (22 in 2003, 25 in 2004; L. Tomyn pers. comm.).

Burrowing owls are a species of concern in environmental impact assessments for pipelines, mining and other industrial activities in the province. Pipeline routes are planned so as to avoid burrowing owl nesting areas if possible, and mitigation techniques, such as the installation of artificial nest burrows, are sometimes employed. In 1999, Scobie and Faminow (2000) compiled a standardized set of guidelines and mitigation strategies for COSEWIC-listed species, including setback distances and timing windows for disturbances. However, the guidelines for setback distances may be inadequate, as they do not apply when existing disturbances (i.e., roads, abandoned well sites) are closer to the nest than the recommended setback distance, regardless of the activity level associated with that existing disturbance (D. Shyry, pers. comm.). In addition, the guidelines are not consistently applied or adhered to, the cumulative effects of disturbances specifically related to oil and gas development are not being addressed and thresholds need to be established (J. Nicholson, pers. comm.). These guidelines must be reviewed and re-assessed from time to time, in the context of cumulative effects of disturbances including the oil and gas sector (A. Todd, pers. comm.).

2. Research – Research on burrowing owl ecology was conducted in the Hanna area between 1986 and 1996. This research focussed on habitat use and characteristics (Schmutz 1989b), return rates and annual survival (Schmutz 1989b, Schmutz et al. 1991a), productivity (Clayton and Schmutz 1995), diet (Schmutz et al. 1991b), census techniques (Schmutz and Wood 1992, Schmutz 1996), genetic and morphological comparison of populations (Wilde 1995), and post-fledging survival and dispersal (Clayton and Schmutz 1999).

Research on diet, foraging and hunting behaviour was conducted in the Eastern Irrigation District between 1998 and 2001 (Sissons 2003, D. Shyry unpubl. data) and is currently being conducted in the OneFour area of southern Alberta (G. Holroyd and H. Trefry pers. comm.). Stable isotope analysis to determine large-scale dispersal and the wintering grounds of Canadian burrowing owls was conducted throughout Alberta as part of a North American study from 1997-2002 (Duxbury 2004); this project is ongoing.

A large-scale nesting success project was initiated in 2003 (T. Wellicome unpubl. data) to examine the natural rate of predation on burrowing owl nests throughout the species' range in Alberta, in order to determine the relationship between nesting success and population change as they relate to fledgling production and adult nest-site fidelity. In addition, data are currently being collected and analysed to help eventually identify potential critical habitat for burrowing owls as a requirement under the *Species at Risk Act*.

Finally, a prairie-wide banding project was initiated in 2004 to attempt to determine the extent of between-year dispersal. Almost 1000 burrowing owls were banded throughout Alberta and Saskatchewan during the first year of this project.

SYNTHESIS

The burrowing owl is widely but sparsely distributed throughout the Mixedgrass and Dry Mixedgrass natural subregions of Alberta. It is now considered to be an uncommon bird in the province. Current estimates suggest that there are between 200 and 400 pairs remaining, and the population continues to decline. The population index calculated from Operation Grassland Community has decreased by 88% since the program's inception in 1989, despite an increase in the number of members reporting the presence or absence of owls on their land. Standardized surveys conducted in the Hanna and Brooks regions provide additional evidence for this ongoing decline, showing 10-year declines of 94% and 58%, respectively. Much of the habitat in Alberta that previously contained burrowing owls is now unoccupied, and the owl's provincial distribution has been reduced such that the species is now absent from a considerable portion of its historical range.

Past and continuing modification of the native prairie environment has likely resulted in the degradation of high quality habitat over much of the owl's range as well as an increase in predator populations, thus potentially reducing nesting success and/or fledgling survival. In some areas, pesticide use, collisions with vehicles, and other anthropogenic factors may be having direct or indirect effects on the owl population. These and other factors may also be negatively affecting the owls in other parts of their breeding range, during migration, and on the wintering grounds, resulting in a decline in Alberta as a result of reduced immigration.

If the population decline in Alberta is to be reversed, we will need a better understanding of the ecology of the burrowing owl throughout its North American range, because dispersal appears to be occurring at a scale much larger than previously thought. What factors could be causing high mortality away from the breeding grounds? How are burrowing mammal populations and habitats changing both on and off the breeding grounds?

What is the true extent of between-year dispersal? Within Alberta, we need to increase our understanding of habitat requirements; specifically, what habitat characteristics are associated with high productivity and nest-site fidelity? What is the extent of habitat degradation, and what effect has this had on dispersal and survival rates? Such insights will greatly aid future management and conservation initiatives, and could improve the outlook for the species in the province.

The primary objective of the 1995 National Burrowing Owl Recovery Plan was to reverse the population decline and subsequently maintain a stable or increasing population averaging at least 3000 pairs on the Canadian prairies, including at least 1500 pairs in Alberta (Hjertaas et al. 1995). As the population continues to decline, it becomes clear that we are far from achieving that objective. Unless the population trend is reversed, all indications show that the burrowing owl is heading towards extirpation from Alberta and from Canada.

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Appendix 1. Definitions of selected legal and protective designations.

A. The General Status of Alberta Wild Species 2000 (after Alberta Sustainable Resource Development 2001)

2000 Rank	1996 Rank	Definitions
At Risk	Red	Any species known to be *At Risk* after formal detailed status assessment and designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Green	Any species that is not *At Risk*, *May Be At Risk* or *Sensitive*.
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species known or believed to be present but which has not yet been evaluated.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	Any species no longer thought to be present in Alberta (*Extirpated*) or no longer believed to be present anywhere in the world (*Extinct*).
Accidental/Vagrant	n/a	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Wildlife Act/Regulation

Species designated as *Endangered* under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation.

Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if limiting factors are not reversed.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2003)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if limiting factors are not reversed.
Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk	A species that has been evaluated and found to be not at risk.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

Appendix 1 continued.

D. Heritage Status Ranks: Global (G), National (N), Sub-National (S) (after Alberta Natural Heritage Information Centre 2002, NatureServe 2004)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6 to 20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21 to 100 occurrences, may be rare and local throughout its range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically > 100 occurrences. Apparently secure.
G5/N5/S5	Typically > 100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated, historical records only.
GH/NH/SH	Historically known, may be relocated in the future.
GNR/NNR/SNR	Unranked—conservation status not yet assessed.

E. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

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